Examining the factors associated with impulsivity in forensic populations

Examining the associative factors for impulsivity in forensic populations: a systematic review

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Word Count: (excluding abstract, figures, tables and references)

Abstract

Background: Elevated levels of impulsivity are considered a significant risk factor for violent behaviour within forensic populations but our knowledge of the causes of impulsivity in forensic populations remains limited. The current review aims to collate and critically evaluate existing research examining the possible associations with impulsive behaviour in forensic populations.

Method: A systematic review of the current literature was conducted. Multiple electronic databases including PsycINFO, MEDLINE, EMBASE, and ProQuest Criminal Justice and Social Sciences were searched. Methodological quality assessment of eligible articles was completed prior to a narrative synthesis of findings.

Results: Nine studies were included for review. Overall, the research was rated to be of "adequate" to "good" quality. Studies were limited in their use of prospective, longitudinal methodological design to assess the relationship between study variables and impulsive behaviour. Factors associated with increased impulsivity which emerged included traumatic brain injury, substance or alcohol misuse, traumatic experiences and sleep problems.

Conclusions: There remains little evidence regarding the underlying factors linked with impulsivity in forensic groups and whether it differs from that in the normal population; a question that will require further research. Those factors associated with impulsivity in forensic populations thus far provide the opportunity for more targeted screening for, and treatment of, impulsivity.

Keywords: Impulsivity, forensic, traumatic brain injury, substances, alcohol, trauma, sleep

Abstract word count: 200

1. Introduction

Worldwide, violent behaviour is a leading cause of death in individuals aged 15-44 years old. In addition to the considerable personal and societal burden there are significant financial costs (Krug, Mercy, Dahlberg & Zwi, 2002; Butchart, Mikton, Dahlberg & Krug, 2015) estimated to be in region of £7 trillion globally (Hoeffler, 2017).

The association between impulsivity and violence is widely recognized in both general offending populations and forensic inpatients (Mudde, Nijman, van der Hulst, & van den Bout, 2011; Fazel, Hayes, Bartellas, Clerci, Trestman, 2016; Meijers, Harte, Meynen & Cuijpers, 2017; Spaans, Molendijk, de Beurs, Rinne & Spinhoven, 2017). Meta-analyses indicate that violent offenders display greater impairment on measures of impulsivity than non-violent offenders and that within offending samples impulsivity is independently associated with increased violence (Janes, O'Rourke, Schwannauer & McIntosh, 2018). Prospective studies also demonstrate a consistent relationship between impulsivity and subsequent violence across offending populations (Abdin, Davoren, Naughton, Gibbons, Nulty, Kennedy, 2013; Bousardt, Hoogendorn, Noorthoorn, Hummelen & Nijman, 2016; Coid, Kallis, Doyle, Shaw & Ullrich, 2015).

Impulsivity is widely recognized as a multidimensional concept, defined as a '*predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to the negative consequences of these reactions to the impulsive individual or to others*' (Moeller, Barratt, Dougherty, Schmitz & Swann, 2001, p. 1784). Perhaps due to the multifactorial nature of impulsive behaviour, there is no unified conceptualization. This has led to a variety of terms being attributed to impulsiveness which predominantly include *disinhibition, impulsivity, self-control and impulse control* (Stein, Hollander & Liebowitz, 1993; Bari & Robbins, 2013). However, the most widely used models of impulsivity draw upon behavioural and personality theories. Initial personality theories categorized impulsivity as a component of the Five Factor Model's Extraversion factor (McCrae & Costa, 1987). Later research attempted to understand impulsivity as a distinct personality trait, however disagreement of which sub-traits comprise impulsivity has led to many interpretations being proposed. Perhaps most notably, Barratt (1993) conceptualized impulsivity as being an aspect of personality that includes lack of inhibition, sensation seeking and extraversion. Assessment of impulsive personality traits is commonly completed through use of self-report measures such as the Barratt Impulsiveness Scale (Patton, Stanford, & Barratt, 1995) and Eysenck Impulsiveness Scale (Eysenck, Pearson, Easting, & Allsopp, 1985). More recently, behavioural models consider impulsivity as comprised of two distinct components; impulsive choice (risky decision making) and

impulsive action (disinhibition) (Reynolds, Ortengren, Richards & de Wit, 2006; Dalley, Everitt & Robbins, 2011). Behavioural aspects of impulsivity are typically assessed using neuropsychological or laboratory measures to examine these state-like impulsive characteristics.

Such is the strength of the association between impulsivity and violence, it is routinely incorporated into risk assessment tools (e.g. the Historical Clinical Risk Management version 3 (HCR-20v3), the Structured Assessment of Violence Risk in Youth (SAVRY) and the Violence Risk Scale (VRS) (Bartel, Borum, & Forth, 2000, Douglas, Hart, Webster, and Belfrage, 2013; Klepfisz, Daffern, & Day, 2016). Studies examining the predictive validity of impulsivity for violence in such tools illustrate its consistent utility for this purpose (Abdin, Davoren, Naughton, Gibbons, Nulty, Kennedy, 2013; Coid, Kallis, Doyle, Shaw & Ullrich, 2015; De Vogel & De Ruiter, 2006).

In contrast with the wealth of literature supporting the relationship between impulsivity and violence there remains a paucity of research exploring the risk factors for impulsive behaviour within this population. A biopsychosocial approach may hypothesize that factors influencing neurodevelopment and damage to key brain regions involved in the underlying processes of impulsivity would increase the likelihood of impulsive behaviour being displayed (Moeller et al, 2001; Dalley, Everitt, & Robbins, 2011). In their review, Dalley and Robbins (2017) concluded that striatal interactions within the prefrontal cortex and hippocampus play a key role in the manifestation of impulsive behaviour.

Forensic populations have been observed to experience increased prevalence of risk factors that may impact on brain development. Forensic patients have often experienced abuse, neglect, lifestyle factors associated with increased risk of neurological impact (including alcohol misuse, substance misuse and diet) and high rates of traumatic brain injury all risk factors for potential alteration in the development or structure of brain regions implicated in impulsiveness (Beech, Carter, Mann & Rothstein, 2017). Spitzer, Chevalier, Gillner, Freyberger & Barnow (2006) found rates of childhood trauma in a forensic population to be 41-69%. Fazel, Yoon & Hayes's (2017) recent meta-analysis examining the prevalence of drug and alcohol disorders in prison populations revealed approximately 25% of all newly incarcerated prisoners, of both sexes, had an alcohol use disorder and similar rates were found for substance use disorders. Early life emotional trauma and substance or alcohol abuse has been shown to negatively alter neurodevelopment including synaptic organisation of neural pathways (Arden & Linford, 2009). Traumatic brain injury can often result in physical damage to the cerebral cortex, with affected frontal regions specifically linked to violent and criminal behaviour (Williams, 2012). A meta-

analysis investigating the prevalence of traumatic brain injury across offending populations discovered a rate of approximately 60% (CI: 48.08 to 72.41) (Shiroma, Ferguson & Pickelsimer, 2010). In their review, Williams et al (2018) conclude that neurological abnormalities are common in offending populations, with areas of the brain responsible for social functioning, empathy and impulse control often affected.

1.1 Objectives of the current review

Epidemiological studies indicate that forensic populations may be more predisposed to experience risk factors thought to increase the likelihood of impulsive behaviour. Given the association between impulsivity and subsequent violence a better understanding of these factors is key in appropriately directing assessment and treatment resources. This review aims to systematically examine the current literature which explores factors associated with impulsivity in forensic settings (Warburton & Stahl, 2016).

2. Method

2.1 Review protocol

The review adopted a standardised protocol submitted to PROSPERO (Centre for Reviews and Dissemination - University of York, 2009) and PRISMA guidelines (Moher et al, 2009) were consulted whilst conducting this review.

2.2 Search strategy

The primary author conducted an exploratory search to ensure a similar review had not previously been carried out using Google search engine and the Centre for Reviews and Dissemination (University of York). No relevant reviews were identified.

The following electronic bibliographic databases were searched from inception until January 2018: PsycINFO, MEDLINE, EMBASE, and ProQuest Criminal Justice and Social Sciences. Databases were searched using BOOLEAN operators and included searching within full text of article. To ensure a broad inclusion of appropriate search terms for the review, existing articles exploring impulsivity and forensic populations were examined. Reference lists of included papers for review were also searched. Final search terms used were:

- Terms related to impulsivity: “impuls*” OR “impulsiveness” OR “impulsive behaviour”, OR “impulse control” OR “inhibitory control” OR “response inhibition” OR “delay discounting” OR “motor inhibition” OR “disinhibition” OR “motor control”

- Terms related to forensic populations: “forensic psychiatr*” OR “personality disordered offender*” OR “mentally disordered offender*” OR “forensic service” OR “forensic inpatient” OR “forensic mental health” OR “inmates with mental illness” OR “secure unit” OR “forensic psycholog*” OR “secure hospital” OR “prison*” OR “convict” OR “offend*”
- Terms associated with empirical studies, specifically predictive research: “predict*” OR “prospective” OR “caus*” OR “associati*” OR “risk” OR “contribut*” OR “factor*” OR “correlat*”

2.3 Study selection criteria

2.3.1 Population

Male and female forensic populations, both adult and juvenile, were considered for this review, inclusive of forensic psychiatric and prison settings. General adult and juvenile mental health samples were excluded as risk factors specific to forensic populations were the focus of this review.

2.3.2 Intervention

Only studies which examined the relationship between a given risk factor and level of impulsivity determined by clinician rating, self-report or behavioural measures were eligible for inclusion.

2.3.3 Outcome

The review considered levels of impulsivity as an outcome (dependent variable) using a published clinician rating, self-report or behavioural measure (for example, a computerised or neuropsychological measure) of impulsivity. In the absence of accompanying self-report or behavioural assessments of impulsivity, studies utilising genetic testing or physiological assessments were excluded.

2.3.4 Study design

This review paper considered a wide variety of studies including observational studies, both prospective and retrospective whereby the focus of the study considered risk factors associated with impulsivity in forensic populations. On this basis, between group studies were excluded. Non-English language studies were not considered due to resource limitations.

2.4 Study selection

A PRISMA flow diagram of search results is displayed in Figure.1 depicting the article search and review process. The initial search yielded 5952 studies of which 2066 were

duplicates. Titles and abstracts were subsequently reviewed by the author using the study selection criteria outlined above which resulted in 291 remaining studies. Full-text review of the remaining articles revealed 8 studies which met inclusion criteria. The reference lists of these studies were hand searched which produced an additional one study. Therefore, a total of 9 papers eligible for final narrative review.

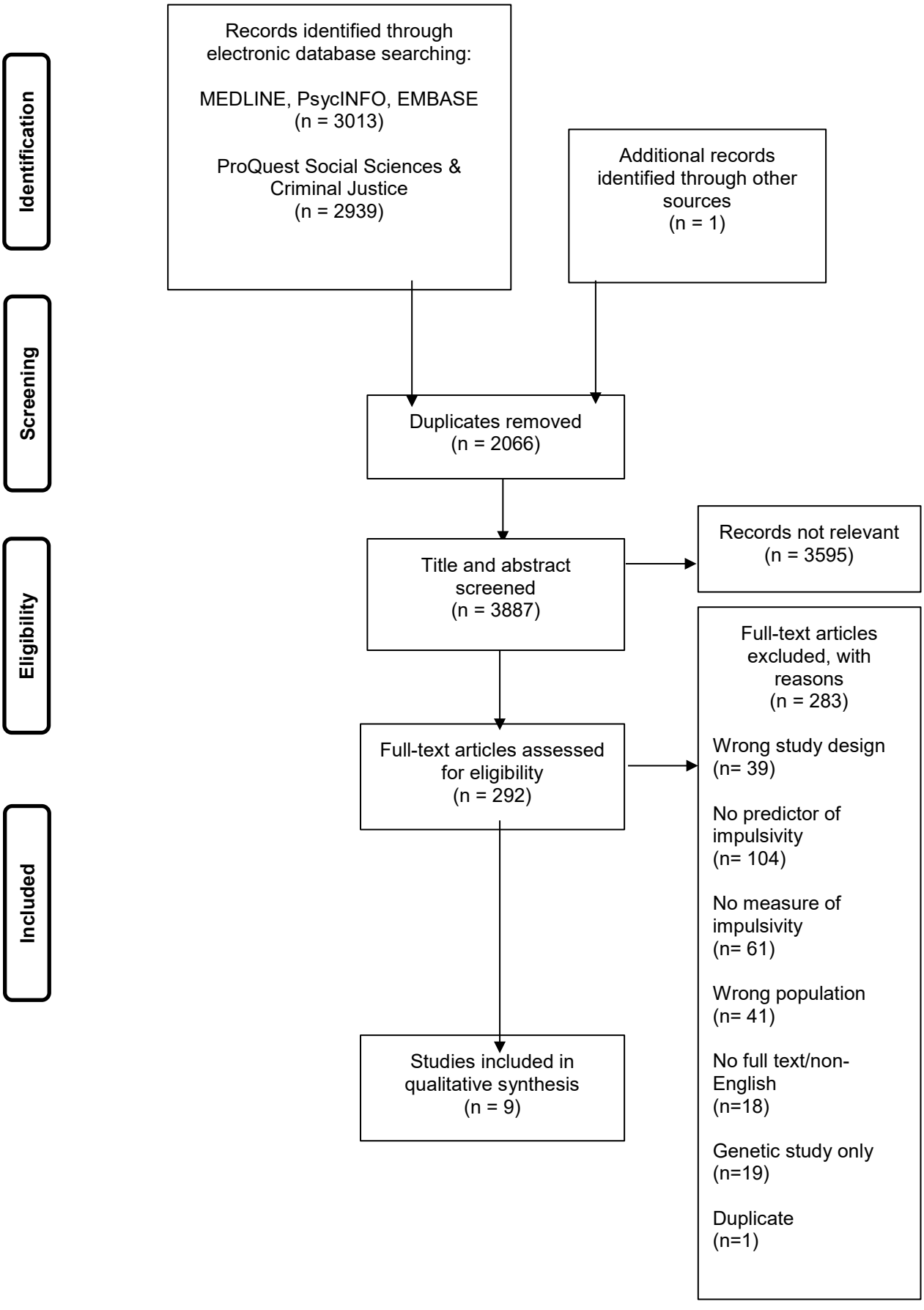
2.5 Quality assessment

In order to assess the quality of studies which met inclusion criteria for the review, the National Institute for Care and Excellence (NICE) Quality Appraisal Checklist for Quantitative Studies Reporting on Correlations and Associations (NICE, 2012), an assessment tool relating to methodological quality, was used. This quality tool was deemed as suitable for the studies included, tailored for the review and comprised 13 questions which considered study rationale and objectives; recruitment of participants; validity and reliability of outcome measures and statistical analyses (see Appendix A). Ratings were allocated by the lead author to each aspect of the study using a three-point Likert-scale system depending on whether the criteria were 'not reported' or 'not met', 'partially met' or 'definitely met' before being awarded an overall quality score (maximum score of 26). Total quality scores were converted into a percentage to easily determine the quality of the studies included in the review. Based on arbitrary cut-offs, studies with a quality percentage of 70% or more were considered to be methodologically more robust. Studies with a percentage score of more than 60% were deemed as being of acceptable quality, whereas studies below these cut-offs were considered as having a poor quality rating (see Appendix B). An independent rater assessed two thirds (n=6) of studies included for narrative review to certify that assessment scores were reliable and valid. Papers for review by the independent rater were selected using a random number generator. Assessors were observed to agree on 92% of items overall, with a substantial inter-rater agreement level achieved (k=0.79) (McHugh, 2012). Consensus was reached through discussion and final ratings agreed upon.

2.6 Data extraction

Information was extracted using a pro-forma which considered inclusion criteria and allowed for systematic recording of key findings. Information extracted included study population, methodology, measure of impulsivity, potential association(s) with impulsivity, statistical analyses and key conclusions.

Figure 1. PRISMA flow diagram of the review process



3. Results

3.1 Study characteristics

Nine full text articles met the inclusion criteria. A summary of study characteristics and findings are shown in Table.1. The majority of articles were cross-sectional in design (n=6), with the remaining studies employing a longitudinal design (n=3). All studies were set in forensic institutions with participants recruited from a prison population (n=3), adolescent offender population (n=4) and forensic psychiatric population (n=2). The total sample of studies reviewed contained 3733 participants comprised of prison population (n=2080); adolescent offender population (n=1545) and forensic psychiatric population (n=208). The mean age of participants included in the nine studies reviewed ranged from M=15.7 years to M=41.9 years. The majority of participants were male (n=4 studies used male only participants), with total number of male participants n=3630 (97%).

3.2 Methodological review

Quality assessment ratings for included studies can be found in Appendix B. Three studies were categorized as having “good” study quality (Carli et al, 2014; Sergentanis et al, 2014; Van Veen, Karsten & Lancel, 2017) obtaining an overall quality score of ≥70%. The remaining six studies were deemed as having “acceptable” quality (>60%) (Bevilacqua et al, 2012; Davis et al, 2017; Kamphuis, Dijk, Spreen & Lancel, 2014; Schwartz, Connolly & Brauer, 2017; Schwartz, Connolly & Valgardson, 2017; Walters & Kiehl, 2015). A number of studies dropped marks due to insufficient information provided to rate specific items as being present, such as recruitment process, inclusion/exclusion criteria and power calculations. However, this may represent poor reporting quality as opposed to methodological flaws. The absence of more objective measures of impulsivity (e.g. neuropsychological or laboratory tasks) applied to all studies (see 3.3 for details).

Three studies were longitudinal and prospective in design (Davis et al, 2017; Schwartz, Connolly & Brauer, 2017; Schwartz, Connolly & Valgardson, 2017) which may be deemed as more methodologically robust in examining the temporal relationship between chosen variables and impulsive behaviour. than the remaining six cross-sectional studies (Carli et al, 2014; Sergentanis et al, 2014; Van Veen, Karsten & Lancel, 2017; Bevilacqua et al, 2012; Kamphius et al, 2014; Walters & Kiehl, 2015).

None of the included studies provided a-priori power calculation, therefore post-hoc analyses were completed using G Power based on sample size and number of tested variables (McCrum-Gardner, 2010). All studies were powered to detect small-medium effect sizes, with a power level of 0.80 and a significance level of <0.05 (Faul, Erdfelder,

Buchner & Lang, 2009). Studies included in the review recruited sample sizes ranging from 96 to 1354.

3.3 Measures of impulsivity

All 9 studies utilized either self-report (n=8) or clinician-rating measures (n=1). No behavioural or neuropsychological measures of impulsivity were used. In the majority of studies, the Barratt Impulsiveness Scale (BIS) (Barratt, Patton & Stanford, 1995) was used to assess impulsivity (n=5). The BIS is arguably the most frequently administered self-report measure used to assess impulsive behaviour, demonstrating good internal consistency (Cronbach's α = .71 for total score) and satisfactory test-retest reliability for use in forensic populations (Haden & Shiva, 2008; Stanford et al, 2009). The BIS contains 30 items attending to motor, attentional and non-planning aspects of impulsivity with a recommended cut-off score of ≥72 to identify individuals who are highly impulsive (Stanford et al, 2009).

In the remaining studies (n=4), subscales from assessment tools focusing on impulsive behaviour were used for analysis: 1) The Disinhibition subscale (4-items examining need for stimulation, lack of realistic long-term goals, impulsivity, and irresponsibility) from the clinician-rated measure, Psychopathy Checklist-Revised (PCL-R - Hare, 1980) was used in one study; and 2) The Impulse Control subscale, drawn from the Weinberger Adjustment Inventory (WAI - Weinberger & Schwartz, 1990) was used in three studies (the 7-item Suppression of Aggression subscale from the WAI was additionally used in one of the reviewed studies). The Impulse Control subscale consists of eight items examining overall behavioural control and demonstrates good internal consistency (Cronbach's α = .79) (Knight et al, 2012). The complete assessment tools from which they derive have been found to be valid and reliable in offending populations (Hare et al, 1990; Huckaby, Kohler, Garner & Steiner, 1998).

Table 1. General characteristics of the 9 studies included for full review

Author	Population (*Country*)	N	Design	Overall quality assessment rating (%)	Impulsivity measure	Total mean impulsivity score
Bevilaqua et al (2012)	Prison (*Italy*)	411	Cross-sectional study	65	Barratt Impulsiveness Scale (BIS - max score: 120)	47.6 (SD±15.6)
Carli et al (2014)	Prison (*Italy*)	1515	Retrospective cross-sectional study	73	Barratt Impulsiveness Scale (BIS - max score: 120)	47.3 (SD±14.8)
Davis et al (2017)	Adolescent offender (*USA*)	1100	Longitudinal study	69	Weinberg Adjustment Inventory (impulse control subscale - max score: 8)	2.92 (SD±0.943)
Kamphius et al (2014)	Forensic psychiatric inpatients (*Netherlands*)	96	Cross-sectional study	62	Barratt Impulsiveness Scale (BIS - max score: 120)	62.4 (SD±1.2)
Schwartz, Connolly & Brauer (2017)	Adolescent offender (*USA*)	1354	Longitudinal study	69	Weinberg Adjustment Inventory (impulse control and suppression of aggression subscales - max score: 15)	5.61 (SD±1.74)

Schwartz, Connolly & Valgardson (2017)	Adolescent offender (*USA*)	1354	Longitudinal study	69	Weinberg Adjustment Inventory (impulse control subscale - max score: 8)	2.96 (SD±0.95)
Sergentanis et al (2014)	Prison (*Greece*)	154	Cross-sectional study	77	Barratt Impulsiveness Scale (BIS - max score: 120)	62 (SD±14.9)
Van Veen, Karsten & Lancel (2017)	Forensic psychiatric inpatients (*Netherlands*)	112	Cross-sectional study	73	Barratt Impulsiveness Scale (BIS - max score: 120)	66.96 (SD±12.08)
Walters & Kiehl (2015)	Adolescent offender (*USA*)	191	Cross-sectional study	62	PCL-R – disinhibition subscale (max score: 8)	5.41 (SD±1.68)

3.4 Potential predictors of impulsivity

All nine articles included for full-text review contained analyses exploring an association between a chosen predictor (independent variable) and impulsivity (dependent variable). Table 2 (cross-sectional studies) and Table 3 (longitudinal studies) detail the potential factors linked with impulsivity examined, statistical analyses and findings. In the reviewed studies, four factors associated with elevated impulsivity were investigated by researchers; traumatic experiences, head injury, substance misuse (illicit drugs or alcohol) and sleep (sleep quality or sleep disorders).

3.4.1 Trauma

The relationship between traumatic experiences and impulsivity was considered in four studies. Traumatic experiences included childhood trauma/maltreatment (Bevilaqcua et al; Carli et al, 2014; Sergentanis et al, 2014) and victimisation, defined as exposure to violence (Davis et al, 2017).

Two studies found that childhood trauma predicted higher levels of impulsivity (Sergentanis et al, 2014; Carli et al, 2014), particularly childhood sexual abuse and physical neglect as rated by the Childhood Trauma Questionnaire (CTQ - Bernstein et al, 2003). One study did not identify a significant association between childhood trauma and impulsivity (Bevilaqcua et al, 2014).

The remaining study examined the relationship between victimisation and impulse control (Davis et al, 2017), assessed using the victimisation subscale of the Exposure to Violence Inventory (Selner-Hagan, Kindlon, Buka, Raudenbush & Earls, 1998). Example items on the EVI included whether participants had been subjected to sexual assault or been attacked with a weapon. Overall findings suggest that higher prevalence of victimisation in early life was associated with poorer impulse control across multiple time points throughout adolescence (Davis et al, 2017).

3.4.2 Head injury and neurological investigations

Two studies explored the relationship between head injury and impulse control (Schwartz, Connolly & Brauer, 2017; Schwartz, Connolly & Valgardson, 2017). Both studies drew their sample from the Pathways to Desistance study, a multi-site longitudinal study of adolescent offenders (Mulvey, 2011). In both studies, head injury was assessed using a single self-reported question asking whether the participant had sustained a head injury, (12 months prior to baseline and subsequently at each follow up assessment for the duration of the study), severe enough to result in loss of consciousness or require medical review. In a series of pathway models (β =.08, p <

.05), Schwartz, Connolly & Brauer (2017) found early head injury was consistently associated with poorer self-control, as assessed by the Suppression of Aggression and Impulse Control subscales of the WAI. Similarly, Schwartz, Connolly & Valgardson (2017) discovered head injury predicted significant decreases in impulse control ($p < 0.001$) as assessed using the Impulse Control subscale across multiple time points using cross-lagged path model analysis.

An additional study included in the review examined the relationship between neurological findings and impulsive behaviour (disinhibition) (Walters & Kiehl, 2015). Findings revealed that lower levels of grey matter volume (GMV) in the hippocampus were significantly associated with increased scores on the Disinhibition subscale of the PCL-R (Hare, 1980), whereas general brain volume and GMV in the amygdala failed to yield a significant relationship with disinhibition scores.

3.4.3 Alcohol and substance misuse

Four studies explored history of alcohol and substance misuse associated with elevated levels of impulsivity (Carli et al, 2014; Davis et al, 2017; Kamphius et al, 2014; Walters & Kiehl, 2015). Alcohol or substance misuse was consistently found to be siggifncatly associated with impulsive behaviour across all studies which included this variable. Interestingly, this relationship was consistently observed even though methods of assessing alcohol or substance use varied greatly across studies. Davis et al (2017) asked participants to respond to a single self-report question related to levels of binge drinking in the past 12 months. Carli et al, (2014) assessed the presence of a substance use disorder through clinical interview by a specially trained psychiatrist or psychologist, while Kamphius et al (2014) reviewed participants' medical case-files to identify whether a history of substance abuse (e.g. yes/no) was present. Walters and Kiehl (2015) utilised arguably a more standardised method, administering the Addiction Severity Index (McLellan, Kusgner, Metzger, Peters, Smith, Grissom & Argeriou, 1992), a brief, semi-structured interview relating to psychosocial aspects of a person's substances use.

3.4.4 Sleep

Two studies examined the relationship between sleep quality and/or disorders of sleep with impulsive behaviour measured using the BIS (total scores) (Kamphius et al, 2014; Van Veen, Karsten & Lancel, 2017). In both studies, elevated self-reported levels of impulsivity were significantly linked with poor sleep quality and insomnia as assessed by the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman & Kupfer, 1989) and the Sleep Diagnosis List (derived from the Sleep Disorder

Questionnaire - Douglass, Bornstein, Nino-Murcia, Keenan, Miles, Zarcone & Dement, 1994) respectively. It is of note that, in contrast, when sleep quality was assessed using structured professional judgement alone in one of these samples, no significant relationship between sleep difficulties and impulsivity was identified (Kamphius et al., 2014)

Author(s)	Predictors(s) of impulsivity	Measure(s) used	Statistical analyses	Statistical findings		Comments
				(B)	*(P)*	
Bevilaqua et al (2012)	1) Childhood trauma	Childhood Trauma Questionnaire (CTQ)	Linear regression	*NR*	0.29	Within the linear regression model, childhood trauma did not have a significant effect on BIS scores.
Carli et al (2014)	1) Childhood emotional abuse	Childhood Trauma Questionnaire (CTQ)	Non-linear logistic regression	0.00058	5.8485	History of substance use disorders, sexual abuse or physical abuse, predicted higher BIS scores.
	2) Childhood sexual abuse				0.0007	
	3) Childhood physical neglect			0.01004	0.0007	
	4) Substance use disorders	Clinical Interview		0.00792	0.0001	
				0.05154		
Kamphius et al (2014)	1) Sleep	The Pittsburgh Sleep Quality Index (PSQI)	Multiple regression	0.92	< 0.001	Sleep quality and insomnia significantly predicted subjective impulsivity. A robust relationship between sleep problems and the structured professional judgement of impulsivity could not be confirmed.
		The Sleep Diagnosis List (SDL)				A history of substance abuse was also a significant predictor of impulsivity.
		History of substance use		6.26	< 0.001	
	2) History of substance use			5.51	< 0.01	
Sergentanis et al (2014)	1) Childhood maltreatment	3-closed questions (≈1 cut off)	Multivariate hierarchical regression	*NR*	0.003	Childhood maltreatment predicted higher rates of impulsivity, as well as aggression, illicit substance and alcohol use, smoking and psychiatric history.

Van Veen, Karsten & Lancel (2017)	1) Sleep	Pittsburgh Sleep Quality Index (PSQI)	Multiple regression	0.742	< 0.01	Sleep quality and insomnia significantly predicted higher rates of impulsivity.
		Sleep Diagnosis List (SDL)		5.223	< 0.001	
Walters & Kiehl (2015)	1) Substance use	Addiction Severity Index (modified version)	Structural equation modelling regression analysis	0.163	0.001	Grey matter volume levels in the hippocampus correlated significantly with disinhibition. Significant relationship between substance use and disinhibition was also detected.
	2) Brain volume	Magnetic resonance imaging (MRI) scans		-0.001	0.629	
	3) GMV amygdala			-0.019	0.891	
	4) GMV hippocampus			-0.436	0.006	

Table 2. Potential predictors of impulsivity - cross sectional studies

NR - not reported
B - regression coefficient
P - significance value

Table 3. Potential predictors of impulsivity - longitudinal studies

Author(s)	Predictors(s) of impulsivity	Measure(s) used	Statistical analyses	Key findings

Davis et al (2017)	1) Binge drinking 2) Trauma (victimization - exposure to violence)	Single self-report question (yes/no) 6-item victimization subscale (Exposure to Violence Inventory)	Auto-regressive latent trajectory with structure residuals model over 7-year period.	Individuals who reported more binge drinking had lower impulse control. Higher victimization also predicted lower impulse control.
Schwartz, Connolly & Brauer (2017)	1) Head injury	Single, self- reported question (yes/no)	Structural equation modeling to examine self-reported head injury as a predictor of starting levels and change in self-control over 7-year period.	Significant associations between head injuries and short-term changes in self-control and subsequent increases in aggressive delinquency.
Schwartz et al (2017)	1) Head injury	Single, self- reported question (yes/no)	Series of autoregressive cross-lagged models in which head injuries at earlier time points were used to predict later measures of impulse control over 7-year period.	The cross-lagged paths consistently demonstrated evidence to suggest that sustaining a head injury was associated with significant decreases in impulse control across multiple time points.

4. Discussion

4.1 Summary of findings

This systematic review is the first to investigate evidence of potential variables associated with impulsive behaviour in forensic populations. Using a structured search strategy, nine studies examining the relationship between potential risk factors and levels of impulsivity in this population were identified and reviewed. The included studies identified early trauma experiences, poor sleep, history of substance or alcohol misuse and neurological involvement (e.g. head injury) as potential risk factors for impulsive behaviour in forensic populations.

The assessment of impulsivity in the reviewed studies was confined to self-report and clinician rated measures. Whilst both approaches are widely used and valid methods of assessment in this population, they also possess limitations which should be acknowledged. For example, self-reported measures in forensic populations may be susceptible to patients under reporting their difficulties, particularly context dependent impulses (Schmidt, Banse & Imhoff, 2015), potentially due to poor introspective abilities or apprehension of being negatively perceived by others. Whereas, clinician rated measures may be considered more subjective and susceptible to inter-rater reliability issues (Ford, 2005). In the reviewed studies, there was an absence of neuropsychological or laboratory measures used to examine the state-like behaviour of distinct impulsive components (e.g. response inhibition or delayed gratification) outlined in recent behavioural models of impulsivity.

Findings illustrated that alcohol and/or substance misuse is the most robust and consistently reported factor associated with impulsivity amongst forensic populations (Carli et al, 2014; Davis et al, 2017; Kamphius et al, 2014; Walters & Kiehl, 2015). That impulsive behaviour is strongly linked to drug and alcohol use, may be argued to be bi-directional in nature. De Wit (2009) hypothesized that impulsivity may simultaneously be a determinant and consequence of substance or alcohol misuse. As a determinant, trait impulsiveness and increases in context dependent state impulsiveness have been shown to increase drug use (Tarter, Kirisci, Feske & Vanyukov, 2007; De Wit, 2009). The acute or long-term effects of drug and alcohol use itself may themselves lead to elevated levels of impulsivity, perhaps due to the impact on neural mechanisms which contribute to the manifestation of impulsive behaviour. For example, alcohol-related brain damage (ARBD) has been associated with structural changes to the brain and subsequent neurocognitive impairment including executive function deficits of response inhibition, poor planning and self-regulation (Bates, Bowden & Barry 2002; Zahr, Kaufman & Harper, 2011).

Incidence of head injury was significantly linked with increased impulsive behaviour in the two studies which examined this (Schwartz, Connolly & Brauer, 2017; Schwartz, Connolly & Valgardson, 2017). Head injury is commonly associated with behavioural, emotional and cognitive changes. These neurobehavioural changes may easily lead to rule breaking behaviour and, as recent literature identifies, individuals in forensic settings are more likely than the general population to have sustained a head injury at some stage in their lives (Williams et al, 2018). It may, therefore be considered surprising that this review yielded only two studies which explored the relationship between head injury and impulsivity in forensic populations, representing a dearth in the current literature. Further knowledge of whether individuals in criminal justice settings who have suffered a head injury, experience poorer outcomes or are more likely to engage in offending behaviours may represent opportunities to improve treatment and management options for this subgroup. For example, Scotland's National Prisoner Healthcare Network (NHS Scotland & Scottish Prison Service, 2016) recommend improvements in the identification of brain injury, as well a consideration of matched care interventions (dependent on severity of brain injury) to help support and manage individuals with brain injury in forensic settings. The need for a training analysis to develop resources and highlight education needs for staff working with brain injured clients in forensic settings was also identified.

The findings of this review were inconsistent regarding the relationship between early trauma and elevated levels of impulsivity. However, in other clinical populations early traumatic experiences have been associated with decreased volume in the hippocampal and amygdala regions of the brain (Hoy et al, 2011). In addition, recent research suggests that early trauma adversely impacts cognitive and neural mechanisms responsible for inhibitory control functions (Marshall et al, 2016). Future studies may wish to further explore early trauma and its associations with distinct components of impulsive behaviour in forensic settings to better understand this relationship.

Sleep difficulties also emerged as a potential factor associated with impulsive behaviour within forensic psychiatric populations. Research investigating sleep problems with cognitive, behavioural and emotional changes is in its infancy. However, a link between poor sleep and behavioural problems may be mediated by the negative impact sleep loss has on the functioning of frontal pathways (Kamphuis, Karsten, de Weerd & Lancel, 2013), and subsequently emotional regulation.

Forensic populations will have often experienced a variety of physical and psychological difficulties throughout the life span (Beech et al, 2017). From the studies included in this review, it is evident that forensic populations may be more likely than general populations to simultaneously experience multiple risk factors thought to increase the likelihood of impulsive behaviour (e.g. poor sleep, history of alcohol/substance misuse, early trauma and head injury), an established predictor of aggressive and violent incidents (Mudde et al, 2011; Bousardt et al, 2016).

It is difficult to draw conclusions as to whether the risk factors that emerged from this review can confidently be considered to cause elevated levels of impulsive behaviour in this population. This is contributed to by the relatively low number of relevant papers available to review and the heterogeneity of variables examined, albeit all studies were sufficiently powered to identify a small or medium effect size. In addition, aspects of research methodology such as the limited number of studies adopting prospective, longitudinal designs allow less opportunity to determine the temporal relationship between risk factors and levels of impulsive behaviour.

4.2 Strengths and limitations of the current review

The current review is not without limitations, which should be acknowledged. Given the low number of studies for each variable and heterogeneity of studies in relation to methodological design, population group and forensic setting, there were insufficient data for meta-analyses. Our decision to adopt an approach that was inclusive of all forensic populations (including prison, young offender and forensic psychiatry), while having the advantage of maximising the number of studies eligible for inclusion, could limit the specificity of our findings should the factors precipitating impulsivity vary between types of settings. For example, research examining developmental trajectories of impulsive behaviour indicate higher baseline levels to be present in adolescence and gradually declining thereafter (Monahan, Steinberg, Cauffman & Mulvey, 2009). It is our hope that the use of percentage ratings assisted readers in appraising the quality of the included papers but acknowledge that our choice of numerical cut-offs to categorise these was arbitrary. Finally, there is potential for a cultural bias as non-English studies were excluded from this review.

This is however the first systematic review to offer a narrative synthesis of potential causes for elevated impulsiveness in forensic settings. It was strict in its inclusion of studies that adopted an associative research design and, while this reduced the number of papers available for final review, those included were better able to elucidate the potential factors which are most strongly linked to impulsive behaviour in this population.

4.3 Implications for future research and clinical practice

There is a dearth of research exploring the relationship between risk factors for impulsive behaviour which adopt prospective, longitudinal methodology and robust outcome measures assessing the distinct components of impulsivity as outlined in recent models (Reynolds et al, 2006; Dalley et al, 2011). There was a notable absence of more objective, behavioural assessment methods utilised in the reviewed studies which may offer an opportunity for future research to examine predictive factors of state-like impulsive behaviours in addition to routinely assessed trait impulsiveness.

It is hoped that these findings will assist those working in criminal justice services or forensic healthcare to identify those most likely to experience difficulties with impulsivity, guiding their approach to assessment and treatment. This is particularly relevant for professionals undertaking risk assessments, where the presence of one or more of the identified risk factors for impulsivity may highlight the need for structured assessment of this factor. Future research may wish to explore whether impulsivity plays a mediating role between risk factors with a neurological basis (e.g. TBI) and violence. Furthermore, we observed there is a paucity of studies estimating the prevalence of impulsivity in forensic populations, which could offer a larger scale opportunity to examine its correlates and potential causes.

4.4 Conclusions

This is the first systematic review to examine factors associated with impulsivity in forensic settings. The conclusions of which are confounded by a limited number of heterogeneous studies which were primarily cross sectional in nature. Potential risk factors for impulsive behaviour which emerged from the review were alcohol or substance misuse, head injury, early trauma and sleep. Further research examining risk factors for impulsivity may wish to adopt longitudinal, prospective methodology utilising more objective, behavioural assessment methods to measure the distinct aspects of impulsivity in line with recent theoretical models of impulsivity.

Appendix A: Quality assessment tool

Operationalised NICE Checklist for Quantitative Studies Reporting on Correlations and Associations
Author: ***Date:*** ***Title:***
Scoring criteria: **Definitely – 2** **Partially - 1** **No – 0** **Not reported – NR**

Item	Score
1. Does the study address an appropriate and clearly focused question (e.g. is there a clinical or theoretical rationale for the research)?	
2. Are the aims of the study specific and appropriate (e.g. clearly outlined 'aims' or 'hypotheses' section that are consistent with rationale in item 1)?	
Population	
3. Is the source area and population clearly described to sufficient detail to allow for comparison and generalisability?	
4. Is the recruitment of eligible population well defined?	
5. Was the method of participant selection from the eligible population well described (e.g. inclusion/exclusion criteria explicit)?	
6. Are descriptive statistics of participants key characteristics provided?	
7. Do the sampled participants appear sufficiently representative of the population?	
Outcome	
8. Were the outcome measures objective?	
9. Did the outcome measures have adequate reliability?	
10. Were the outcome measures well validated?	
Analyses	
11. Was the study sufficiently powered to detect an intervention effect (e.g. with a power of 0.8, it is likely to see an effect of a given size if one exists, 80% of the time)?	
12. Are the statistical methods appropriate for the study design (for example, impulsivity as dependent variable in statistical analysis)?	
13. Were confidence intervals or p values for effect estimates given or possible to calculate?	
Internal & external validity	Tick one as appropriate
++ All or most of the checklist criteria have been fulfilled, where they have not been fulfilled the conclusions are very unlikely to alter	
+ Some of the checklist criteria have been fulfilled, where they have not been fulfilled, or not adequately described, the conclusions are unlikely to alter	
- Few or no checklist criteria have been fulfilled and the conclusions are likely or very likely to alter	

Appendix B: Quality assessment scores for each included paper

	Bevilacqua et al (2012)	Carli et al (2014)	Davis et al (2017)	Kamphius et al (2014)	Schwartz, Connolly & Brauer (2017)	Schwartz, Connolly & Valgardson (2017)	Sergentanis et al (2014)	Van Veen, Karsten & Lancel (2017)	Walters & Kiehl (2015)
1. Clear study rationale	2	2	2	2	2	2	2	2	2
2. Specific study aims	2	2	2	2	2	2	2	2	2
3. Cleary described source area	2	2	2	2	2	2	1	2	1
4. Recruitment process well defined	2	2	1	1	1	1	2	2	1
5. Explicit inclusion/exclusion criteria	1	2	1	0	1	1	2	1	2
6. Descriptive statistics	1	1	1	2	1	1	2	2	1
7. Well represented sample	1	1	2	1	2	2	2	1	0
8. Objective outcome measure(s)	1	1	1	1	1	1	1	1	2
9. Reliable outcome measure(s)	1	1	1	1	1	1	1	1	1
10. Validated outcome measure(s)	1	1	1	1	1	1	1	1	NR
11. Power calculation	NR	NR	NR	NR	NR	NR	NR	NR	NR
12. Appropriate statistical analyses	2	2	2	2	2	2	2	2	2
13. Stats available for effect estimates	1	2	2	1	2	2	2	2	2
Total quality (max 26)	**17**	**19**	**18**	**16**	**18**	**18**	**20**	**19**	**16**
Total quality (%)	**65**	**73**	**69**	**62**	**69**	**69**	**77**	**73**	**62**